The Chromodoridinae Nudibranchs from the Pacific Coast of America. - Part IV. The Genus *Hypselodoris*

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(1 Plate; Text figures 26 to 32)

THIS PAPER IS THE FOURTH and concluding part of The Chromodoridinae Nudibranchs from the Pacific Coast of America. Previous segments have discussed various techniques and criteria for opisthobranch systematics, and supra-specific taxonomy of the CHROMODORIDIDAE (BERTSCH, 1977), and known species of the genera *Chromodoris* (BERTSCH, 1978a), *Chromolaichma* and *Mexichromis* (BERTSCH, 1978b).

Hypselodoris Stimpson, 1855

Hypselodoris agassizii (Bergh, 1894)

(Figures 3-L, 26, 29 - 32)

References and Synonymy:

Chromodoris agassizii BERGH, 1894: 182 - 183; plt. 7, figs. 14 - 22. BERGH, 1898: 533. BERGH, 1905a: 71. COCKERELL & ELIOT, 1905: 36. BERGH, 1905b: 156. MACFARLAND, 1906: 129. BERTSCH, 1970: 7

Glossodoris agassizi (Bergh). PRUVOT-FOL, 1951a: 78 - 79. ABBOTT, 1974: 355, fig. 4250 [first figure so numbered, bottom left hand side of the page]

Hypselodoris agassizi (Bergh). SPHON, 1971: 214. SPHON & MULLINER, 1972: 150 - 151. MARCUS & HUGHES, 1974: 520.

Chromodoris aegialia BERGH, 1904: plt. 4, figs. 19 - 22. BERGH, 1905a: 70 - 71. COCKERELL & ELIOT, 1905: 36. MACFARLAND, 1906: 129. BERTSCH, 1970: 8.

Glossodoris aegialia (Bergh). PRUVOT-FOL, 1951a: 78. ABBOTT, 1974: 355.

Hypselodoris aegialia (Bergh). KEEN, 1971: 823. SPHON, 1972b: 65. BERTSCH *et al.*, 1973: 292. BERTSCH, 1973: 109. BERTSCH, 1976b: 158.

Hypselodoris californiensis (not Bergh, 1879). MARCUS & MARCUS, 1967: 176 - 178 (in part); fig. 31 (locality 2). MARCUS, 1971: 357 (in part). KEEN, 1971: 823 (in part); fig. 2335. BRUSCA, 1973: 174 (in part); fig. 6.68.

Hypselodoris agassizii (Bergh). SPHON, 1972b: 65. BERTSCH *et al.*, 1973: 289, 292. BERTSCH, 1973: 109. BERTSCH & FERREIRA, 1974: 344. FERREIRA & BERTSCH, 1975: 326 to 327; figs. 7-8. KEEN & COAN, 1975: 43 (in part). Anonymous, 1975: 6. BERTSCH, 1976b: 158. BERTSCH & MEYER, in prep.

Material Examined and Distribution:

Baja California, Mexico:

1) 1 specimen, Isla Espíritu Santo (24°25'N; 110°21'W); *leg.* A. J. Ferreira, 27 November 1973 (HB 367)
2) 1 specimen, La Paz area; *leg.* E. Janss Jr., no date

Mainland Mexico and Central America:

3) 2 specimens, Puerto Peñasco, Sonora; *leg.* G. E. & N. MacGinitie, 23 - 27 December 1948 (HB 439 A-B; CAS)
4) 1 specimen, Cabo Tepoca, Punta Lobos, Sonora; *leg.* F. & R. Poorman, March 1975 (HB 426; LACM A 8477)
5) 1 specimen, Bahía San Carlos, Sonora; *leg.* A. J. Ferreira, August 1972
6) 1 specimen, Morro Colorado, near Guaymas; *leg.* A. Kerstitch, May, 1972
7) 6 specimens, La Cruz, Nayarit; *leg.* F. & R. Poorman, 3 January 1976 (HB 417 A-F; LACM A 8477)
8) 5 specimens, intertidal, Bahía Banderas, Jalisco; *leg.* H. DuShane, 24 February 1971 (HB 387 A-E; LACM A 8530)
9) 2 specimens, Isla Pajaro, Panama; *leg.* P. W. Glynn, 21 May 1972 (HB 264 A-B)

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Editor's Note: For Figures 3-A, 3-B, etc. see The Veliger 20 (2): 115

10) 1 specimen, Contadora Island, Panama; *leg.* A. F. Ferreira, February 1975 (HB 368)
11) 1 specimen, intertidal, Culebra Island, Balboa, Panama; *leg.* H. Bertsch & K. B. Meyer, 7 August 1974 (HB 132)
12) 1 specimen, subtidal, Taboguilla Island, Panama; *leg.* G. Hendler, 30 August 1974 (HB 192)
13) 1 specimen, Taboguilla Island, Panama; *leg.* G. Hendler, 30 August 1974 (HB 193)
14) 1 specimen, Taboguilla Island, Panama; *leg.* G. Hendler, 6 September 1974 (HB 205)
15) 1 specimen, Taboguilla Island, Panama; *leg.* G. Hendler, 11 September 1974 (HB 219)
16) 1 specimen, Culebra Island, Panama; *leg.* H. Bertsch & K. B. Meyer, 17 September 1974 (HB 221)
17) 1 specimen, Culebra Island, Panama; *leg.* H. Bertsch & K. B. Meyer, 17 September 1974 (HB 222)

South America:

18) 1 specimen, Academy Bay, Santa Cruz Island, Galápagos Islands; *leg.* A. G. Smith, February 1964

Published records of the occurrence of *Hypselodoris agassizii* are the Gulf of California from mainland, Sonora, Mexico (Puerto Peñasco, Cabo Tepoca, Puerto Libertad, and Guaymas) and Baja California (Salatito Bay and Pulmo Reef), from southern Mexico (Sayulita, Nayarit; and Bahía Banderas, Jalisco), Central America (Bahía Ballenas, Costa Rica; and the type locality, Panama Bay, Panama), and one specimen from the Galápagos Islands (Ferreira & Bertsch, 1975: 327).

White (1952: 116-118; fig. 16) reported a specimen from Florida as *Glossodoris aegialia*. This is erroneous; the specimen was probably *Hypselodoris edenticulata* (White, 1952).

External Morphology and Coloration:

Living specimens from Panama ranged from 18-29 mm in total length ($\bar{X} = 21.8$mm, $n = 6$). Body color is dark blue. On the notum and lateral and posterior sur-

Table 13

Radular Variation in *Hypselodoris agassizii*

Specimen (HB numbers)	Length (in mm)	Width (in mm)	Width: length ratio	Number of tooth rows	Maximum number of teeth per half-row	Maximum number of smooth teeth per half-row
[1]	–	–	–	65	105	–
[2]	–	–	–	51	85	–
205	2.44	1.64	1:1.49	68	92	72
219	2.53	1.43	1:1.77	58	73	0
221	1.43	0.91	1:1.57	47	56	–
222	1.52	1.05	1:1.45	52	64	–
264 A	2.87	2.28	1:1.26	71	103	92
264 B	4.69	3.39	1:1.38	80	110	–
367	1.19	0.79	1:1.51	48	50	–
368	4.34	3.54	1:1.23	80	118	96
387 B	3.84	2.77	1:1.39	71	117	95
387 C	3.47	2.38	1:1.46	69	100	87
387 D	4.12	2.81	1:1.47	76	110	93
387 E	3.17	2.32	1:1.37	64	92	79
417 A	3.05	2.3	1:1.33	66	118	90
417 B	3.35	2.24	1:1.5	66	113	94
417 C	2.24	1.62	1:1.38	58	95	77
417 D	1.818	1.212	1:1.5	56	80	45
417 E	2.53	1.37	1:1.85	61	94	68
417 F	2.44	1.78	1:1.37	65	87	69
426	2.83	2.28	1:1.24	69	96	73
439 A	2.77	2.04	1:1.36	66	79	58
439 B	4.24	3.03	1:1.4	72	102	85
$\bar{X}$	2.89	2.056	1:1.44	64.3	93	74.88
s	0.984	0.785	0.153	9.29	19.2	23.99

[1]Bergh, 1894; [2]Marcus & Marcus, 1967.

faces of the foot are numerous small yellow (or orangish) dots. At times there are also elongate, ovalish white marks on the notum; one specimen from Panama had 2 longitudinal rows of the white marks (each with 2 spots on the anterior half of the dorsum, and 3 spots on the posterior half of the dorsum in front of the gills). Bergh (1894: 182) described this variation (of larger white streaks) in the original description of *Hypselodoris agassizii*, although he was using preserved material in which the yellow had faded: "... überall am Rücken und an den Seiten eine Menge von kleinen ovalen weissen Punkten oder Fleckchen vorkam, welche hier und da durch Verschmelzen kurze Striche und einzelne Flecken bildeten." The amount and size of the white streaks vary in different animals; Marcus & Marcus (1967: 177; fig. 31) studied a specimen which had only 1 white streak posterior to the right rhinophore.

Surrounding the mantle edge are 3 colored stripes; a light green one innermost, a yellow band on the outside, and a navy blue or black band between. These stripes are broken anteriorly (in front of the rhinophores) and laterally (approximately in the middle of the animal's length). Rhinophores are dark blue, with small yellowish

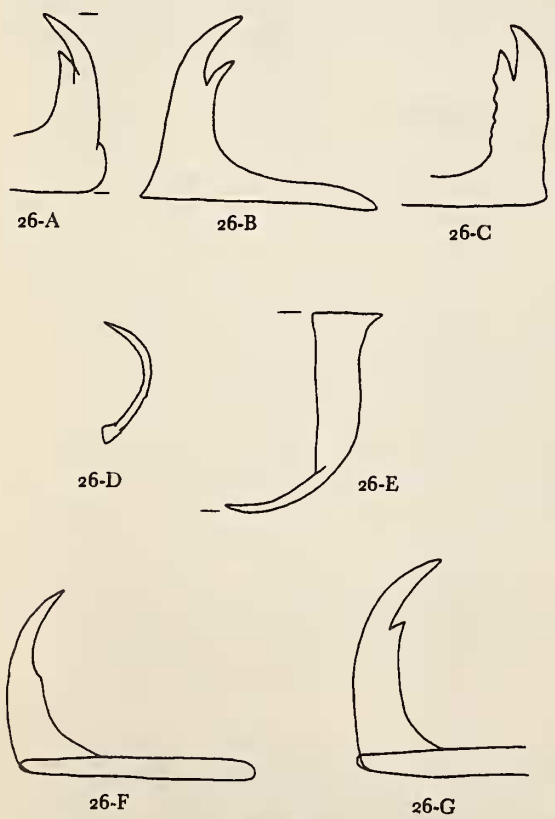

Figure 26

Radular teeth of *Hypselodoris agassizii*

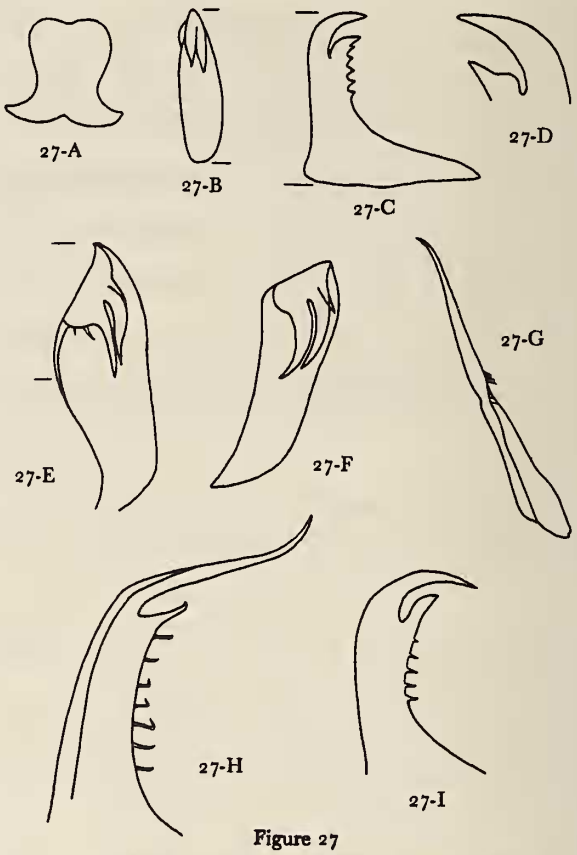

Figure 27

Radular teeth of *Hypselodoris californiensis*

A – HB 360; outline sketch of radula mounted flat
B – HB 406; 1st lateral tooth, row 26, RSR; LBM, 0.038 mm
C – HB 406; tooth 69, row 26, RSR; LBM, 0.06 mm; length of base, 0.06 mm
D – HB 407; distal shaft, 2 main cusps of an inner lateral tooth
E – HB 360; developing innermost tooth, row 68 (penultimate), LSR; LBM, 0.026 mm
F – HB 360; developing innermost tooth, row 66, LSR
G – HB 407; developing outermost lateral tooth, row 87 (ultimate), LSR; total length, 0.093 mm
H – HB 407; developing inner lateral tooth, row 87 (ultimate), LSR
I – HB 252 C; nearly fully-formed lateral tooth (inner ⅛ of half-row), row 52, LSR

(← adjacent column)

A – HB 439 A; smooth inner lateral, tooth 28, row 28, LSR; LBM, 0.09 mm
B – HB 387 B; smooth inner lateral, tooth 84, row 21, LSR
C – HB 387 D; denticled outer lateral tooth, row 31, RSR
D – HB 387 C; developing lateral tooth, row 69 (ultimate); LBM, 0.03 mm
E – HB 387 D; developing lateral tooth, row 67, LSR; LBM, 0.08 mm
F – HB 387 D; developing lateral tooth, row 60, LSR; LBM 0.073 mm; length of base, 0.105 mm
G – HB 387 D; developing lateral tooth, row 59, LSR; LBM, 0.078 mm

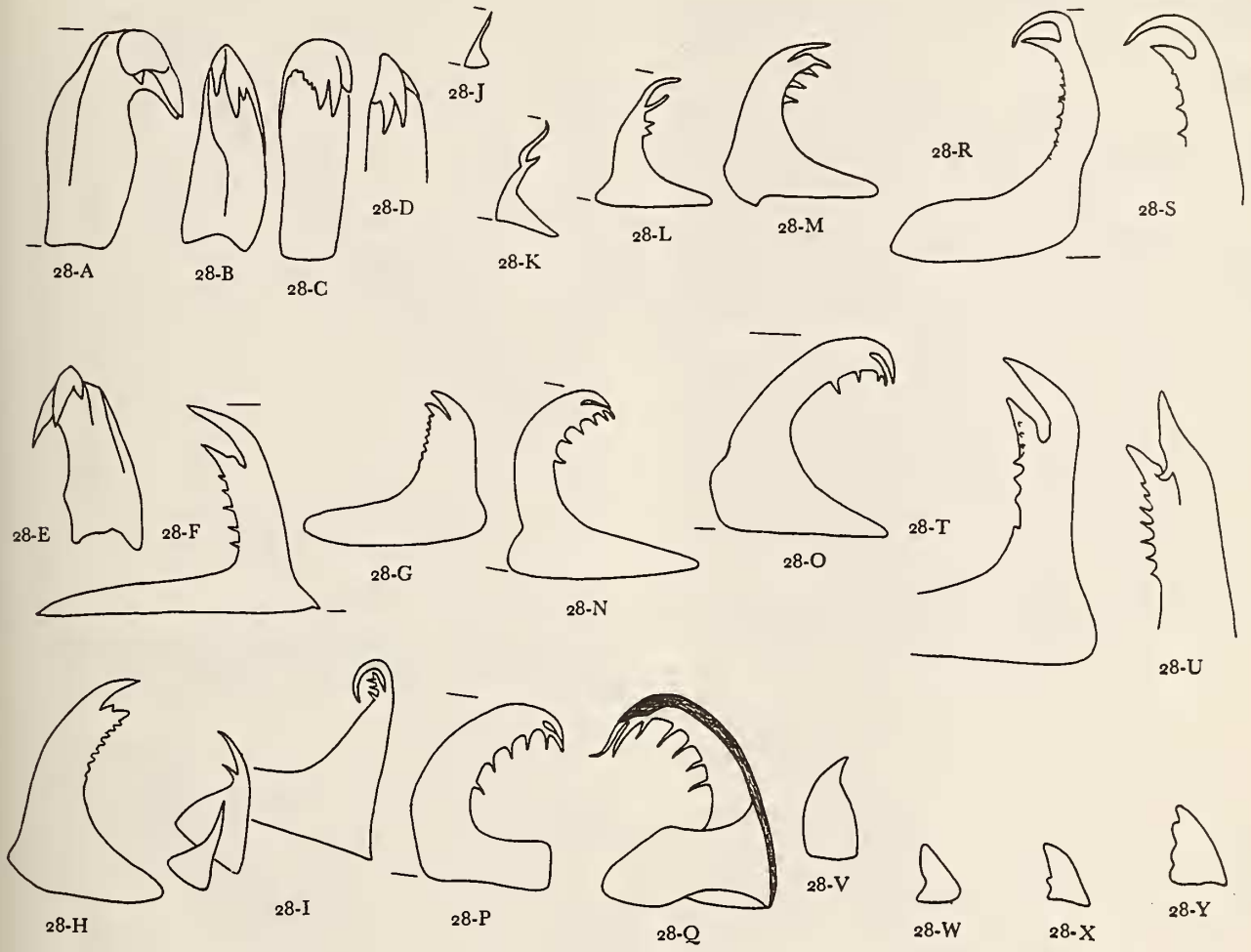

Figure 28

Radular teeth of *Hypselodoris* ***ghiselini***

A – HB 86 A; innermost lateral tooth, row 20, RSR; LBM, 0.065 mm; a ridge (or flange) is visible along the left (inner) side of the base; the bicuspid tip and the denticle on the distal inner surface of the shaft are also shown

B – HB 318 D; innermost lateral tooth, row 28, LSR

C – HB 318 B; innermost lateral tooth, row 29, LSR

D – HB 428 A; innermost lateral tooth, row 38, LSR

E – HB 428 A; innermost lateral tooth, row 37, LSR; LBM, 0.054 mm; visible are the bicuspid tip and denticle on inner surface (upper left of figure), and the lengthwise basal flange (right side of figure)

F – HB 26; representative lateral tooth from middle of half-row; LBM, 0.074 mm; length (measured from base of notch between 1st and 2nd cusps to cusp tip) of primary cusp is 0.028 mm, and of secondary cusp is 0.018 mm; base of tooth 0.097 mm

G – HB 318 B; isolated lateral tooth from anterior portion of radula

H – HB 89; lateral tooth from middle of half-row, approximately row 27, RSR

I – HB 318 D (USNM 753567); developing teeth in 3 successive rows (drawn in relative proportion and position); smallest tooth is 3rd newest row of radula, largest is 5th

J - Q – HB 318 C; sequence of developing teeth, last row, from center of radula to outer edge

J – LBM, 0.019 mm

K – LBM, 0.042 mm

L – LBM, 0.038 mm (curvature of shaft increases; measurement made to greatest height, not along entire shaft, and hence this tooth is shorter than the younger tooth figured in 28K)

M – LBM, 0.048 mm

N – LBM, 0.034 mm

O – LBM, 0.044 mm

P – LBM, 0.044 mm

Q – Tooth is thickened along the anterior ridge

R - U – HB 86-B; sequence of developing lateral teeth from center of half-rows

V – HB 100 A; jaw platelet; 0.024 mm long

W - Y – HB 87; jaw platelets; all approximately the same size, 0.01 mm high, 0.008 mm wide

flecks. Gills are white basally, with the distal tips dark blue.

Radula:

Meristic characters of 23 radulae (including the reported data from 2 radulae by BERGH, 1894, and MARCUS & MARCUS, 1967) are in Table 13. The data reported for *Chromodoris aegialia* BERGH (1905a: 71) were not used for the calculation of means nor regression lines. The combined radular formula is 47 - 80 (50-118·0·50-118) (including *C. aegialia*, the known maximum number of tooth rows is 85).

The number of tooth rows and maximum number of teeth per half-row are positively correlated (Figure 29). The regression line formula is $Y = -18.01 + 1.726X$; $r = 0.8349$, $P < 0.001$, $n = 23$.

The number of tooth rows is dependent on the length of the radula (Figure 30). The equation for the regression line is $Y = 39.57 + 8.74X$. The coefficient of correlation is 0.9295 ($P < 0.001$, $n = 21$).

The maximum number of teeth per half-row is positively correlated with the radular width (Figure 31).

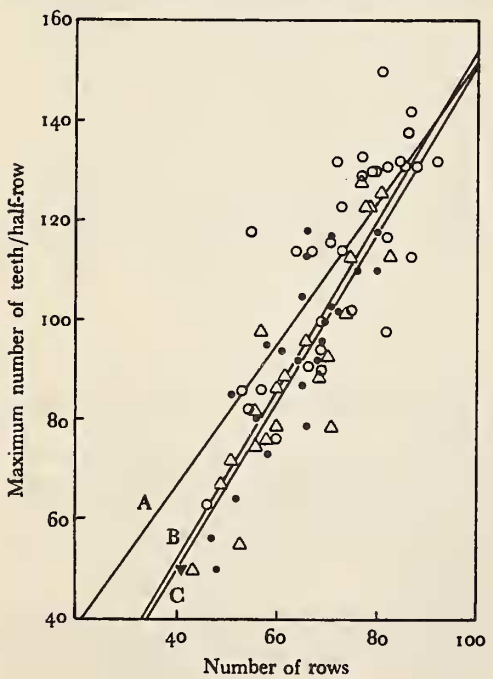

Figure 29

Correlation between maximum number of teeth per half-row and number of tooth rows. A – *Hypselodoris agassizii* (dots); B – *H. californiensis* (○); C – *H. ghiselini* (△); and *H. lapislazuli* (▲)

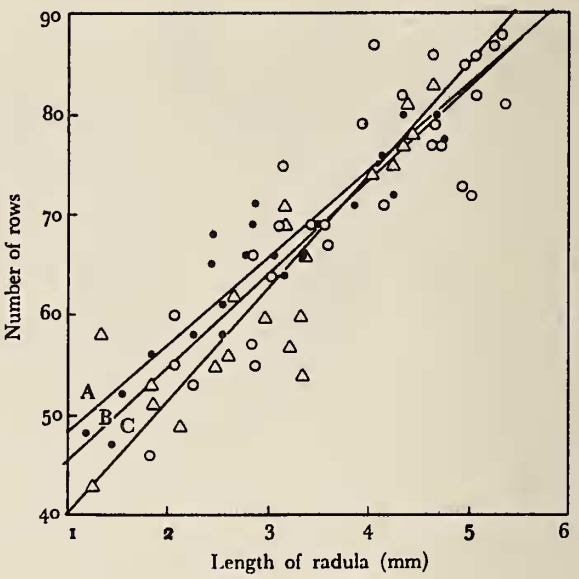

Figure 30

Relation between number of rows and length of radula, *Hypselodoris agassizii*, *H. californiensis*, and *H. ghiselini*. Symbols as in Figure 29

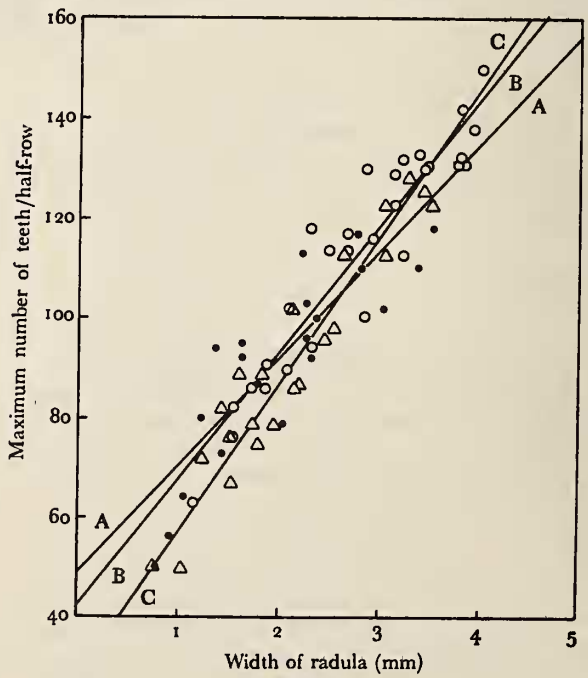

Figure 31

Correlation between maximum number of teeth per half-row and width of radula, *Hypselodoris agassizii*, *H. californiensis*, and *H. ghiselini*. Symbols as in Figure 29

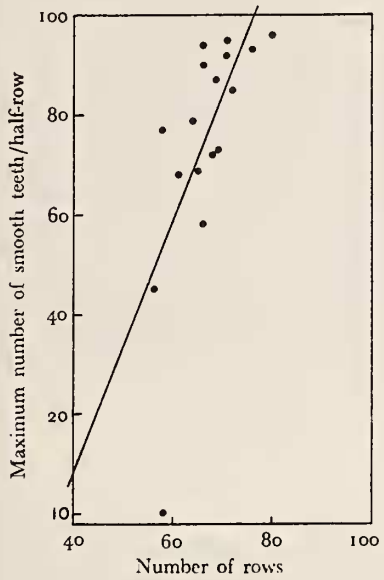

Figure 32

Correlation between maximum number of smooth teeth per half-row and number of tooth rows, *Hypselodoris agassizii*

The formula, $Y = 48.84 + 21.38\,X$, describes the regression line ($r = 0.8439$, $P < 0.001$, $n = 21$).

The maximum number of smooth (without denticles) lateral teeth per half-row is dependent on the number of rows (Figure 32). The regression line formula is $Y = -95.82 + 2.55\,X$ ($r = 0.6786$, $P < 0.01$, $n = 17$).

Radular teeth are bicuspid (Ferreira & Bertsch, 1975: figs. 7 - 8, scanning electron micrographs of the lateral teeth). The inner lateral teeth have no denticles (Figure 26 A-B), but outermost teeth are denticled (Figure 26 C). The number of smooth teeth is a function of the size of the radula. The smooth lateral teeth were noted by Bergh (1894: 183), but overlooked in recent works (Marcus & Marcus, 1967: 178; Sphon, 1971: 214). This is an important characteristic; and even considering the ontogenetic change of this quality, it clearly separates *Hypselodoris agassizii* from *H. californiensis, H. **ghiselini,*** and *H. lapislazuli.*

Stages of development of the smooth lateral teeth are shown in Figure 26 D - G. The tooth begins as a small, curled, sickle-shaped, pointed hook, then thickens and elongates, as the primary cusp becomes prominent. The secondary cusp is initially a small point, which lengthens as the entire tooth becomes larger.

Discussion:

Chromodoris aegialia was described in 1904 from a single preserved specimen collected in the Gulf of California. It has remained an enigmatic species since that original description, included for completeness in taxonomic and faunal lists only as a reference to Bergh's report.

Based on the known range of color variation of *Hypselodoris agassizii*, its radular morphology and the regression analyses of its meristic qualities, I conclude that *Chromodoris aegialia* is a junior subjective synonym of *Hypselodoris agassizii.*

Bergh (1905a: 70 - 71) describes *Chromodoris aegialia* as greenish-white, with various rows of white streaks and dots, 4 small white bands around the mantle border, and 2 - 3 lengthwise rows of short white streaks and flecks. Living *Hypselodoris agassizii* has a dark blue notal center, with rows of yellow streaks and dots, and usually 3 colored bands around the mantle border, and 3 or 4 irregular rows of yellow spots on the sides of the foot. The overall impression of the two is similar; differences are attributable to preservation artifacts. There is no compelling reason to consider the coloration different.

The probable similarity of the species seen by their external coloration, is made definitive by an examination of the radula. The specimen named *Chromodoris aegialia* has bicuspid lateral teeth, with no denticles. All the lateral teeth are smooth. The radular formula Bergh gives is 85 (110·0·110). The number of smooth lateral teeth of *Hypselodoris agassizii* increases with the larger number of tooth rows (Figure 32). Plotting the number of tooth rows of *C. aegialia* results in a point adjacent to the calculated regression line of *H. agassizii* (the line crosses 80 rows at 110 smooth teeth per half-row), well within the expected (and statistically derived) range of variation for *H. agassizii.* The specimen that Bergh described as *C. aegialia* is simply a large *H. agassizii* in which all the lateral teeth are without denticulation.

Hypselodoris californiensis (Bergh, 1879)

(Figures 3-M, 27, 29 - 31, *61 - 64*)

References and Synonymy:

Chromodoris californiensis Bergh, 1879c: 72, 109, 112 - 114. Bergh, 1884: 649. Orcutt, 1885: 545. Bergh, 1890a: 168; plt. 3, fig. 14. Bergh, 1890b: 940. Bergh, 1891: 141. Bergh, 1892: 118. Bergh, 1898: 533. Bergh, 1905a: 71. Cockerell & Eliot, 1905: 36, 37 - 38. Bergh, 1905b: 156. MacFarland, 1906: 129 - 130. Cockerell, 1908: 106. Johnson & Snook, 1927: 494, plt. 9, fig. 4. MacGinitie & MacGinitie, 1949: 379. MacFarland, 1966: 157 - 162; plt. 24, figs. 1 - 3; plt. 34, figs. 12 - 23. Russell, 1968: 140 - 141. Bloom, 1976: 293, 294.

Chromodoris calensis Bergh, 1879a: 3. Bergh, 1879b: 103. Bergh, 1880: 125, plt. 14, figs. 5 - 15.

Chromodoris glauca Bergh, 1879b: 88, 103, 106 - 107. Bergh, 1879a: 3 (*nomen nudum*). Bergh, 1879c: 109. Bergh, 1884: 649. Bergh, 1890a: 168. Bergh, 1890b: 940.

Bergh, 1891: 141. Bergh, 1892: 118. Bergh, 1905b: 156.

Glossodoris glauca (Bergh). Pruvot-Fol, 1951a: 106.

Chromodoris universitatis Cockerell, 1901: 79. Cockerell, 1902: 19 - 20. Cockerell & Eliot, 1905: 36, 37-38. MacFarland, 1906: 129 - 130.

Glossodoris universitatis (Cockerell). Pruvot-Fol, 1951a: 90. Pruvot-Fol, 1951b: 152. Abbott, 1974: 355.

Chromodoris sp. Guernsey, 1912: 75; figs. 39 C - D.

Glossodoris californiensis (Bergh). O'Donoghue, 1926: 211. O'Donoghue, 1927: 90 - 91; plt. 2, figs. 38 - 42. Smith & Gordon, 1948: 180. Pruvot-Fol, 1951a: 89 - 90. Pruvot-Fol, 1951b: 152. White, 1952: 114. Steinberg, 1961: 62. Lance, 1961: 66. Paine, 1963: 4, 8. Farmer & Collier, 1963: 62. Steinberg, 1963: 69. Lance, 1966: 69, 70, 72 (may be only in part). Farmer, 1967: 341. Sphon & Lance, 1968: 79. Ricketts & Calvin, 1968: 119, 514. Abbott, 1974: 355 (in part); fig. 4250 (second illustration with that number, upper right hand quarter of the page).

Hypselodoris californiensis (Bergh). Marcus & Marcus, 1967: 59, 176 - 178 (in part; not any of the material examined nor figures), 238. Farmer, 1968: 24 - 25. Roller & Long, 1969: 425 - 429. Roller, 1970a: 371. Long, 1970: 19. McBeth, 1971a: 28. Keen, 1971: 823 (in part, not fig. 2335); plt. 20, fig. 1. McBeth, 1971b: 158. Sphon, 1971: 214 (in part). Farmer, 1971: 19. Sphon & Mulliner, 1972: 150. Sphon, 1972b: 65. Bertsch *et al.*, 1973: 287. Bertsch, 1973: 109. Brusca, 1973: 174 (in part; not fig. 6.68). Ferreira & Bertsch, 1975: 326 - 327. Keen & Coan, 1975: 44. Smith & Carlton, 1975: 528, 540.

Bergh had intended the species name to be *calensis*, but the typesetter changed it in the text to *californiensis*; since the text was printed before the plate (on which *calensis* remained unaltered), the name *californiensis* has priority (which Bergh accepted in his subsequent articles). In his other two 1879 papers, Bergh mentions the name *calensis* only in lists. Therefore, the name *Chromodoris calensis* in Bergh, 1879a and 1879b is a *nomen nudum*, and *C. calensis* Bergh, 1880, is a synonym. The valid original description of this species occurs in Bergh, 1879c, as *C. californiensis*.

The synonymy of *Hypselodoris californiensis* with *Chromodoris universitatis* and Guernsey's (1912) *Chromodoris* sp. has been long established (Cockerell & Eliot, 1905, and O'Donoghue, 1926). The new synonymization with *C. glauca* needs an explanation.

Bergh (1879b) described 2 specimens in the Berlin Museum as *Chromodoris glauca*. His text is nothing more than an external description of preserved *Hypselodoris californiensis*. The background color, arrangement of spots, and light mantle margin band are all diagnostic of *H. californiensis*. The name *C. glauca* has priority over *H. californiensis*, but *C. glauca* has appeared in the literature only once in the last 70 years (in the list of Pruvot-Fol, 1951a: 106; she writes, "Mieux connue, cette espèce devra probablement être assimilée à l'une des *Glossodoris* bleues de California"). In contrast, *H. californiensis* is a very well-known species, reported often in the literature. To maintain stability, I treat *C. glauca* as a *nomen oblitum*, mentioning it as a synonym of *H. californiensis* only for the sake of completeness. The International Commission of Zoological Nomenclature will be petitioned to place *C. glauca* on the Official Index of Rejected Names.

Material Examined and Distribution:

California:

1) 1 specimen, subtidal, Santa Cruz Island; *leg.* R. Ames, 22 February 1963 (HB 446; CAS)
2) 1 specimen, 7.5 m subtidal, Anacapa Island; *leg.* M. Roach, 19 July 1971 (HB 410; LACM)
3) 1 specimen, Fisherman's Cove, Santa Catalina Island; *leg.* C. Swift, 14 August 1970 (HB 406; LACM A 9325)
4) 1 specimen, 13.5 m subtidal, Catalina Island; *leg.* A. J. Ferreira, October 1972 (HB 366)
5) 1 specimen, 15 m subtidal, Isthmus, Catalina Island; *leg.* A. J. Ferreira, 9 July 1975 (HB 360)
6) 1 specimen, 27 - 33 m subtidal, 2.7 km NW of Pyramid Head, San Clemente Island; *leg.* C. Swift, 1 July 1971 (HB 407; LACM)
7) 1 specimen, 13.5 m subtidal, San Clemente Island; *leg.* C. Gage, 18 September 1971 (HB 412; LACM A 9942)
8) 1 specimen, 15 - 18 m subtidal, Cortez Bank, Los Angeles County; *leg.* C. Swift, 22 September 1971 (HB 408; LACM)
9) 1 specimen, Newport Bay; *leg.* G. E. MacGinitie, 19 June 1949 (HB 441; CAS)

Explanation of Figures 63 to 68

Scanning electron micrographs of the radular teeth of *Hypselodoris californiensis* and *Hypselodoris ghiselini*

Figure 63: *Hypselodoris californiensis*; developing lateral teeth (HB 252 B) × 675

Figure 64: *Hypselodoris californiensis*; developing lateral teeth (HB 252 B) × 675

Figure 65: *Hypselodoris ghiselini*; overall view of anterior portion of radula × 125

Figure 66: *Hypselodoris ghiselini*; outermost lateral teeth × 375

Figure 67: *Hypselodoris ghiselini*; outermost lateral teeth × 1300

Figure 68: *Hypselodoris ghiselini*; jaw elements × 3850

Figure 63

Figure 64

Figure 65

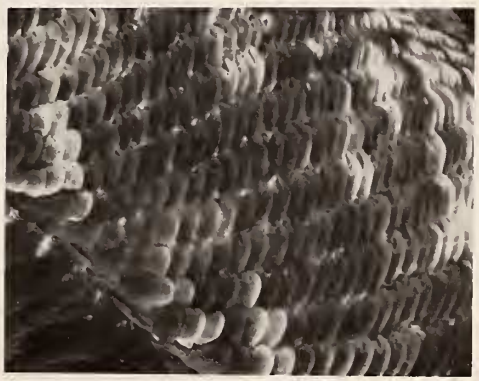

Figure 66

Figure 67

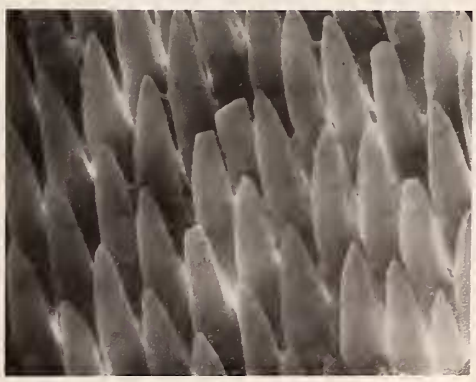

Figure 68

10) 1 specimen, Laguna Beach; *leg.* W. A. Hilton, 1915 (HB 445; CAS)
11) 1 specimen, Laguna Beach; *leg.* A. B. Burch, 15 May 1936 (HB 447; CAS)
12) 2 specimens, Arch Rock, Corona del Mar; *leg.* G. E. MacGinitie, 31 October and 29 November 1932 (HB 442 A-B; CAS)
13) 1 specimen, Corona del Mar; *leg.* G. E. MacGinitie, 26 December 1932 (HB 444; CAS)
14) 1 specimen, La Jolla; *leg* T. D. A. Cockerell, 21 March 1902 (HB 437; CAS)
15) 1 specimen, San Diego; *leg.* A. J. Ferreira, 21 July 1974 (HB 369)

Mexico:

16) 4 specimens, Isla Coronado; *leg.* A. J. Ferreira, 28 September 1973 (HB 423 A-D; LACM A 9549)
17) 6 specimens, Isla San Martin; *leg.* A. J. Ferreira, 25 September 1973 (HB 252 and 425 A-C; LACM A9549)
18) 1 specimen, 6 - 12m subtidal, Sacramento Reef, S of Isla San Geronimo; *leg.* J. McLean, 26 - 27 September 1971 (HB 411; LACM 71-19)
19) 1 specimen, 13.5 - 18m subtidal, Thurloe Head (27°37′31″N; 114°50′37″W); *leg.* J. McLean & P. La Follette, 23 October 1971 (HB 413; LACM 71-170)
20) 2 specimens, Man-of-War Cove, Bahía Magdalena; *leg.* J. McLean & P. La Follette, 31 October 1971 (HB 414 B-C; LACM 71-183)
21) 1 specimen, 23m subtidal, on reef between Islas Calaveras Smith, Bahía de Los Angeles; *leg.* N. Michel & D. Mulliner, 11 October 1975 (HB 424)
22) 2 specimens, no data (HB 409 A-B; LACM)

It is difficult to determine the known distribution of *Hypselodoris californiensis*, because records of 3 species (*H. californiensis, H. agassizii,* and *H. ghiselini*) have often been lumped together. It is necessary to distinguish definite, indefinite, and incorrect records. *Hypselodoris californiensis* has been reported correctly from the following localities along the Pacific coast of California and Baja California: Monterey, Carmel, Santa Barbara County, San Pedro, Santa Catalina Island (type locality), Laguna, Newport Bay, Corona del Mar, La Jolla, San Diego Bay (see MacFarland, 1966: 162, and Sphon & Lance, 1968), and Isla Coronado (Lance, 1961). In the Gulf of California it has been reported reliably from Isla Angel de la Guarda (Farmer, 1963), and Cabo Tepoca (Puerto de Lobos), Sonora (Farmer, 1971). The Gulf of California records in Farmer (1967) and Lance (1966) are indefinite. They cannot be assigned definitely to any one of the 3 possible species. Lance's (1966: 72) statement, that Bergh (1894: 181) had reported *H. californiensis* from the region of Bahía Magdalena, is incorrect. Bergh's locality (24°11′N; 109°55′W) is in the Gulf of California between Isla Cerralvo and Las Cruces; moreover, Bergh's specimen was not *H. californiensis*, but *H. ghiselini*. MacFarland (1966: 162) lists 3 localities in the Gulf of California as collecting sites of *H. californiensis*. The first locality ("off La Paz") refers to *H. ghiselini*; the 2 collections at Puerto Peñasco are indeterminable to species. The range given in Keen (1971: 823) includes all 3 species.

The reliable occurrences of *Hypselodoris californiensis* in the Gulf of California are from Bahía de Los Angeles and Cabo Tepoca. It should be noted that the waters of Bahía de Los Angeles (to 30m) have cooler temperatures year-round than other regions in the Gulf of California (Robinson, 1973), and a large number of Californian species have been reported in this region (data from Keen, 1971, pers. observ., and G. G. Sphon, pers. comm.). Californian species normally exhibiting tropical submergence in the Panamic province may be found intertidally and in the shallow subtidal regions of Bahía de Los Angeles.

External Morphology and Coloration:

Hypselodoris californiensis attains a length of 71mm. The overall body color is a deep blue; large yellow dots or streaks occur on the notum (a transverse row of them anterior to the rhinophores, another row between the rhinophores, and 2 lengthwise rows along the side of the notum between the midline and the lateral edges) and in 1 - 2 rows along each side of the foot. The edge of the mantle and foot is bordered by a very light blue or whitish band of color (Bertsch, 1973: 109). MacFarland (1966: plt. 24, figs. 1 - 3) and Keen (1971: plt. 20, fig. 1) present colored illustrations of *H. californiensis*.

Radula:

The meristic characters of 32 radulae are in Table 14. The overall range of variation is 42 - 92 rows, with maxima of 63 - 150 teeth per half-row.

There is a positive correlation between the number of tooth rows and the maximum number of teeth per half-row. The regression line is described by the formula $Y = 9.48 + 1.423\,X$; $r = 0.7757$, $P < 0.001$, $n = 32$.

The number of tooth rows is dependent on the radular length. The regression line formula is $Y = 36.18 + 9.28\,X$. The coefficient of correlation is 0.8783, $P < 0.001$, $n = 29$.

The radular width and maximum number of teeth per half-row are positively correlated. The formula, $Y = 42.52 + 25.395\,X$, describes the regression line ($r = 0.9407$, $P < 0.001$, $n = 29$).

Bergh (1879), O'Donoghue (1927) and MacFarland (1966) have described the radular teeth morphology. Figure 27 A is an outline sketch of an entire, flat-

Table 14

Radular Variation in *Hypselodoris californiensis*

Specimen (HB numbers)	Length (in mm)	Width (in mm)	Width: length ratio	Number of tooth rows	Maximum number of teeth per half-row
[3]	–	–	–	82	98
[4]	–	–	–	73	114
[5]	–	–	–	92	132
252 C	4.63	3.15	1:1.47	77	129
360	3.11	2.08	1:1.495	69	90
366	3.03	2.5	1:1.21	64	114
369	3.41	2.83	1:1.20	69	100
406	2.08	1.54	1:1.35	55	82
407	4.08	3.21	1:1.27	87	113
408	4.95	3.11	1:1.59	73	123
409 A	4.67	3.43	1:1.36	79	130
409 B	3.6	2.67	1:1.35	67	114
410	4.16	2.91	1:1.43	71	116
411	4.97	3.8	1:1.31	85	132
412	2.89	2.3	1:1.26	55	118
413	3.94	2.87	1:1.37	79	130
414 B	2.24	1.72	1:1.3	53	86
414 C	2.83	1.88	1:1.51	66	91
423 A	4.73	3.39	1:1.395	77	133
423 B	4.65	3.45	1:1.35	86	131
423 C	5.09	3.92	1:1.298	86	138
423 D	5.01	3.21	1:1.56	72	132
424	2.08	1.54	1:1.35	60	76
425 A	5.31	3.88	1:1.37	88	131
425 B	5.27	3.8	1:1.39	87	142
437	3.54	2.32	1:1.53	69	94
441	5.09	3.8	1:1.34	82	131
442 A	2.85	1.88	1:1.52	57	86
442 B	1.84	1.15	1:1.6	46	63
444	5.39	4.02	1:1.34	81	150
445	4.34	2.69	1:1.61	82	117
446	3.13	2.1	1:1.49	75	102
$\bar{X}$	3.89	2.8	1:1.4	73.25	113.68
s	1.108	0.824	0.116	11.769	21.58

[3]Bergh, 1879 c; [4]MacFarland, 1966; [5]O'Donoghue, 1927.

tened radula. The first lateral tooth (Figure 27 B, E-F) has a small denticle (almost forming a 3rd cusp) on the inner surface adjacent to the base of the cusps (figured also by MacFarland, 1966: plt. 34, fig. 12-13). The lateral teeth (Figure 27 C-D, *61*) have the typical *Hypselodoris* bicuspid appearance, with denticles on the posterior surface. The extreme outermost lateral teeth become smaller, with greatly reduced cusps (Figure *62*). Developing lateral teeth are shown in Figures 27 E - I, *63*, and *64*).

Discussion:

Hypselodoris californiensis has been mentioned frequently in the literature, but the majority of the citings are comparisons or parts of complete taxonomic listings. The species is encountered most often subtidally in southern Californian waters.

McBeth (1971b: 158) reports that *Hypselodoris californiensis* feeds on the sponge *Stelletta estrella* de Laubenfels, 1930, and *Haliclona* sp.

Hypselodoris ghiselini Bertsch, spec. nov.

(Figures 3-N, 28, 29 - 31, *65 - 68*)

References and Synonymy:

Hypselodoris californiensis (not Bergh, 1879). Bergh, 1894: 181 - 182; plt. 7, figs. 23 - 38. Marcus & Marcus, 1967: 59, 176 - 178 (in part; material of locality 1); figs. 30, 32 - 33. Keen, 1971: 823 (in part). Marcus, 1971: 357 (in part). Sphon, 1971: 214 (in part). Sphon, 1972b: 65 (in part). Marcus & Hughes, 1974: 520

Chromodoris californiensis (not Bergh, 1879). MacFarland, 1966: 162 (in part; reference to Bergh's specimen from "off La Paz")

Glossodoris californiensis (not Bergh, 1879). Abbott, 1974: 355 (in part)

Hypselodoris sp. Farmer, 1971: 19. Bertsch, 1973: 108 to 109. Keen & Coan, 1975: 44. Bertsch, 1976b: 158

Some specimens of this new species have been reported previously as *Hypselodoris californiensis*. The synonymy encompasses only those reports of specimens definitely referable to *H. ghiselini*.

The radular meristic characters of Bergh's (1894) specimen match those of *Hypselodoris ghiselini*, not those of *H. californiensis*; hence his report is actually of *H. ghiselini*.

Material Examined and Distribution:

Baja California, Gulf Coast:

1) Holotype. 2 - 3 m subtidal, Bahía Las Cruces (24°13′ N; 110°05′ W); *leg.* Michael T. Ghiselin, H. Bertsch, & J. Allen, 1 July 1974 (HB 88). This dissected specimen and its mounted radula have been deposited in the collections of the Los Angeles County Natural History Museum, LACM Type Series, No. 1849

2) Paratypes. 2 specimens, 2 - 3 m subtidal, Nopolo and Juncalito; *leg.* H. Bertsch, M. Ghiselin, and J. Allen, 27 June 1974 (HB 86 A-B)

3) 1 specimen, intertidal, Puertecitos; *leg.* H. Bertsch, T. M. Gosliner, and G. C. Williams, 27 March 1972

4) 2 specimens, subtidal, Isla San Marcos; *leg.* E Janss, Jr., April 1974 (HB 432 A-B; LACM A 9555)

5) 1 specimen near Loreto; *leg.* M. Ghiselin, H. Bertsch, and J. Allen, 27 June 1974 (HB 87)

6) 1 specimen, Notri; *leg.* H. Bertsch, M. Ghiselin, and J. Allen, 4 July 1974 (HB 89)

7) 4 specimens, 14 m subtidal, S end of Isla San Diego; *leg.* E. Janss, Jr., April 1974 (LACM)

8) 1 specimen, Los Islotes; *leg.* A. J. Ferreira. July 1971 (identified from a color transparency)

9) 1 specimen, intertidal, San Gabriel Bay, Isla Espíritu Santo (24°29′N; 110°27′W); *leg.* G. G. Sphon, 31 March 1974 (HB 431; LACM 74-31)

10) 1 specimen, Las Cruces; *leg.* G. Lombard, July-August 1972 (HB 100 A)

11) 1 specimen, 3 - 4 m subtidal, bay N of Punta Gorda, 8 km S of Las Cruces; *leg.* H. Bertsch, 22 July 1972 (HB 26)

Mainland Mexico, Gulf Coast:

12) 6 specimens, Puerto Peñasco, Sonora; *leg.* P. Pickens, 9 June 1964 and 15 June 1965 (HB 318 A-F; USNM 753560; this is the material from locality 1 of Marcus & Marcus, 1967: 176 - 178)

13) 2 specimens, Cabo Tepoca, Punta Lobos, Sonora; *leg.* F. & R. Poorman, October 1975 (HB 428 A-B; LACM A 8477)

14) 3 specimens, intertidal, Bahía San Carlos, Sonora; *leg.* F. & R. Poorman, October 1975 (HB 427 A-C; LACM A 8477)

15) 3 specimens, intertidal, Bahía San Carlos; *leg.* F. & R. Poorman, 1 December 1975 (HB 429, 430 A-B; LACM A 8477)

16) 1 specimen, Guaymas, Sonora; *leg.* A. Kerstitch, July 1971 (identified from a color transparency)

The type locality of *Hypselodoris ghiselini* is Las Cruces, Baja California del Sur, Mexico. It has been collected from numerous intertidal and subtidal localities throughout the Gulf of California. The known range is nearly the entire Baja California Gulf coastline, from Puertocitos to Punta Gorda, and on the mainland Mexico coast from Puerto Peñasco to Guaymas.

External Morphology and Coloration:

Holotype specimen measured 35 mm total length when alive. Lengths of other living animals were 30, 57, 66, and 69 mm.

Coloration of animal a deep navy blue (color illustration in Martin, 1977: 18); the notum is covered with numerous small, bright yellow specks. Along the side of the body are 4 - 5 irregular rows of many small bright yellow maculations. There are whitish-blue spots scattered on the notum; they are far less numerous than the yellow markings, and vary in number from just a few to over a dozen. Bottom of the foot is unmarked, a solid deep blue color. Rhinophores and gills are navy blue, with yellow dots on the inner sides of the gills. Seven specimens had 9 - 12 gills each; one specimen had 17 perfoliations to each rhinophore.

Radula:

The sizes, counts, and means of meristic characters of 23 radulae are presented in Table 15. The combined radular formula is 43 - 83 (50 - 128 · 0 · 50 - 128).

The number of tooth rows and maximum number of teeth per half-row are positively correlated (Figure 29). The regression line formula is $Y = -18.34 + 1.7X$ ($r = 0.8895$, $P < 0.001$, $n = 23$).

Table 15

Radular Variation in *Hypselodoris ghiselini*

Specimen (HB numbers)	Length (in mm)	Width (in mm)	Width: length ratio	Number of tooth rows	Maximum number of teeth per half-row
[6]	–	–	–	70	93
26	4.36	3.31	1:1.32	77	128
86 A	4.24	3.05	1:1.39	75	113
86 B	4.4	3.43	1:1.28	81	126
87	4.46	3.54	1:1.26	78	123
88	1.88	1.25	1:1.15	51	72
89	3.86	3.07	1:1.26	79	123
100 A	2.63	1.62	1:1.62	62	89
318 A	4.65	2.66	1:1.75	83	113
318 B	3.13	1.82	1:1.72	69	89
318 C	3.19	1.74	1:1.83	71	79
318 D	2.32	1.52	1:1.53	58	76
318 E	4.08	2.12	1:1.92	74	102
427 A	3.31	2.2	1:1.5	60	87
427 B	2.48	1.45	1:1.71	55	82
427 C	1.25	0.77	1:1.62	43	50
428 A	2.61	1.8	1:1.45	56	75
428 B	3.35	2.46	1:1.36	66	96
429	1.82	1.05	1:1.73	53	55
430 A	3.37	2.18	1:1.55	54	86
430 B	2.12	1.55	1:1.37	49	67
431	3.21	2.55	1:1.26	57	98
432 B	2.99	1.98	1:1.51	60	79
$\bar{X}$	3.169	2.14	1:1.5	64.39	91.35
s	0.96	0.786	0.213	11.47	21.97

[6] Marcus & Marcus, 1967.

Regression analysis (Figure 30) shows also that the number of rows is dependent on the length of the radula ($Y = 28.84 + 11.138\,X$). The coefficient of correlation is 0.9181, $P < 0.001$, $n = 22$.

The radular width and maximum number of teeth per half-row are positively correlated (Figure 31). The formula, $Y = 32.8 + 27.296\,X$, describes the regression line ($r = 0.9545$, $P < 0.001$, $n = 22$).

Tooth morphology has been described by Marcus & Marcus (1967) and Bergh (1894). Figure *65* is an *in situ* view of the anterior portion of the radula. The innermost lateral tooth in each half-row (Figure 28 A-E) has a lengthwise flange along the inner side of the base; there is a single denticle (long enough to give a tricuspid appearance to the distal portion of the tooth shaft) on the inner face at the level of the cusp bases. The outer face has 3 - 4 denticles. Towards the middle of the tooth row the teeth increase in length, with 4 - 10 denticles ($\bar{X} = 7.23$, $s = 1.46$, $n = 42$) on the posterior surface (Figure 28 F-H). The outer lateral teeth (Figures *66, 67*) decrease in size, with the cusps becoming shorter and the base of the shaft thickening along the antero-posterior axis.

Figure 28-I and R - U show developing teeth in progressively more anterior rows. A sequence of developing teeth from the most posterior row is shown in Figure 28 J - Q. Older teeth are towards the more lateral portions of the tooth row. Tooth growth proceeds from the outer margins towards the center of the half-row, and as the tooth rows become progressively more anterior.

Jaw elements (Figures 28 V - Y and *68*) are triangular, with pointed ends.

Discussion:

The external coloration of *Hypselodoris ghiselini* readily distinguishes it from *H. californiensis*. The yellow maculations are much smaller (always dot-like) and more numerous in *H. ghiselini*; there is no light color band on the edge of the notum and the background color is darker. *Hypselodoris californiensis* has larger (and fewer) yellow marks, that often are in the form of elongate streaks, and a light-colored band surrounding the edge of the mantle margin. These are not ontogenetic characters, because these differences exist for large and small specimens of both species.

Etymology:

This species is named after Dr. Michael T. Ghiselin, who collected the holotype specimen, in recognition of his work on opisthobranch phylogeny.

Hypselodoris lapislazuli (Bertsch & Ferreira, 1974) *comb. nov.*

(Figure 30)

References and Synonymy:

Thorunna lapislazuli Bertsch & Ferreira, 1974: 343 - 345; figs. 1, 5 - 9. Keen & Coan, 1975: 44. Bertsch, 1976b: 158.

Material Examined and Distribution:

No additional specimens have been found since the type lot. *Hypselodoris lapislazuli* is known only from the Galápagos Islands.

External Morphology and Coloration:

Preserved lengths of the 4 known specimens vary from 4 - 6mm. Coloration consists of light blue, navy blue, and orange yellow (Bertsch & Ferreira, 1974: fig. 1). An irregular dorso-median stripe of light blue begins anterior to the rhinophores, widens just behind the rhinophores and then becomes thinner, continuing back to just before the gills. A large area of dark navy blue completely encloses the mid-dorsal light blue stripe, with a patch of navy blue extending across the notum at about ½ the animal's length. This navy blue region is randomly covered with dots and splotches of orange and light blue. The mantle is edged completely by a light blue band. The tail protrudes out behind the posterior portion of the mantle, and has a navy blue streak down its center, which is dotted with orange patches; a light blue band occurs on the border of the foot. The 6 simply pinnate gills and the rhinophores are navy blue, with whitish tips.

Radula:

The known radular formula is 41 (47 - 51 · 0 · 47 - 51). The teeth are typically bicuspid (see the scanning electron micrographs in Bertsch & Ferreira, 1974: figs. 5 - 9), with up to 5 denticles on the posterior surface below the secondary cusp of the erect shaft.

Discussion:

Reexamination of scanning electron micrographs of the radula, and a better understanding of the genus *Thorunna* necessitate the shift of this species to *Hypselodoris*. What was thought to be a thin prong on the inner face of the innermost lateral tooth is actually the dorsal portion of an upward-curled flange that runs lengthwise along the inner side of the tooth. Such a flange occurs in other species of *Hypselodoris* (e. g., *Hypselodoris ghiselini*, fig. 28 A, and *H. ruthae* Marcus & Hughes, 1974, pers. obser.). The width and shape of the innermost tooth of *H. lapislazuli* is not the extremely broad-based shape (becoming at least twice as wide posteriorly as it is anteriorly) of *Thorunna*, and should not be included in that genus. The genus *Thorunna*, therefore, is not known from the Pacific coast of America, but is confined to the Indo-Pacific basin, north to Japan and east to Hawaii.

Hypselodoris lapislazuli has a color pattern similar to *Mexichromis tura* and *M. antonii*, but each has distinctively different patterns. *Hypselodoris lapislazuli* has a light blue margin, yellow-orange dots on a deep blue background on the mid-lateral portions of the notum, with a light blue patch down the center of the notum. *Mexichromis antonii* has yellow and black bands surrounding the free edge of the notum, with a light blue background color on which are streaks and patches of darker blue laterally, and magenta and white centrally. *Mexichromis tura* has a yellow band around the free edge of the notum, followed by a light blue region surrounding the lateral portions of the notum, with a dark blue central region in which are numerous small yellow dots.

Discussion of *Hypselodoris*

Too few specimens of *Hypselodoris lapislazuli* are known to compare it statistically with the other 3 species of *Hypselodoris* from the Pacific coast of America; the other 3 can be reliably distinguished from radular characteristics, in addition to the coloration differences already noted. Significant differences between these species are summarized in Table 16. The means used to calculate the t-tests are given in Tables 13 - 15. *Hypselodoris californiensis* has a larger and wider radula, with more tooth rows and

Table 16

Results of t-tests Conducted between Species Pairs of 3 American Pacific Coast *Hypselodoris*. Numbers are significance probabilities (P). N.S.: not significant, no difference between the species for the particular measurement or count.

Hypselodoris:	*californiensis*	*ghiselini*
agassizii		
Rows/teeth	N.S.	N.S.
Length/rows	N.S.	N.S.
Width/teeth	N.S.	N.S.
Length	<.01	N.S.
Width	<.01	N.S.
W:L ratio	N.S.	N.S.
Rows	<.01	N.S.
Max. teeth	<.001	N.S.
californiensis		
Rows/teeth		N.S.
Length/rows		N.S.
Width/teeth		N.S.
Length		<.02
Width		<.01
W:L ratio		<.05
Rows		<.01
Max. teeth		<.001

a larger maximum number of teeth per half-row than *H. agassizii*, but the width:length ratios of these 2 species are the same. The denticles on the inner lateral teeth also distinguish *H. californiensis* from *H. agassizii*. *Hypselodoris californiensis* is larger in all measured parameters (including the width:length radular ratio) than *H. ghiselini*. It is important to emphasize that the width:length ratio is different, because this excludes the possibility of the radular differences being ontogenetic. The coloration differences have been discussed already. *Hypselodoris agassizii* and *H. ghiselini* are identical in their meristic characters. However, the presence or absence of denticles on the inner lateral teeth clearly separates the 2 species.

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